REMARKS

The applicants thank the Examiner for the thorough examination of the application. Attached to this paper, please find a print-out of a slide presentation prepared by Jong Jin Park to better point out the distinctions of the invention over the applied art. The specification has been amended to correct minor errors. No new matter is believed to be added to the application by this Amendment.

Status Of The Claims

Claims 1-11 are pending in the application. Claims 7 and 9 have been amended in a non-narrowing manner to improve their language, and the amendments to claims 7 and 9 are not directed at overcoming the applied art rejection. The Examiner has acknowledged the allowability of claim 10.

Rejection Under 35 U.S.C. 103(a) Over Aoki in View of Anazawa and Irving

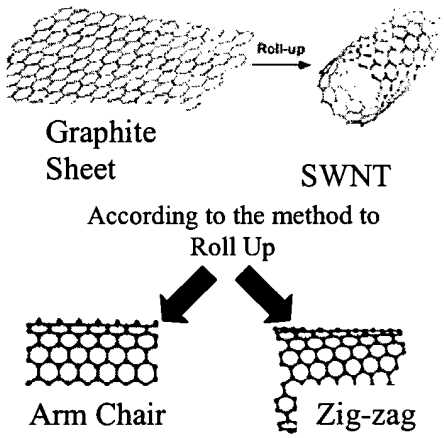
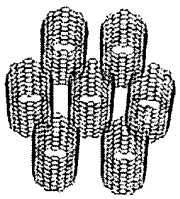
Claims 1-9 and 11 are rejected under 35 U.S.C. 103(a) as being obvious over Aoki (U.S. Patent No. 5,561,026) in view of Anazawa (U.S. Publication No. 2001/0050219 A1) and Irving (U.S. Patent No. 4,439,291). Applicants traverse.

The Present Invention And Its Advantages

The present invention pertains to a method of forming a patterned film of carbon nanotubes via a photolithography process by using surface-modified

carbon nanotubes, whereby double-bond-containing functional groups are introduced into the surfaces of the carbon nanotubes. More specifically, the present invention relates to a method of forming a negative pattern of carbon nanotubes by modifying carbon nanotubes by introducing double bond-containing functional groups that can go through radical polymerization into the surfaces of the carbon nanotubes.

The structure and functions of carbon nanotubes are set forth below.

type	structure	Physical properties
Single Wall		Size : 1000 times as small as commercial Carbon or Glass Fiber (CNT: ϕ 1.4nm) Electrical aspect : having Band Gaps properties. -> Semi-conductive properties Mechanical aspect : High Aspect Ratio > 1000 (Max. 100um synthesizable) Outstanding Strength
Multi-Wall	 Rolled-up with several sheets	
Rope	 Formed of rope of SW and MW.	

The present invention has many embodiments. However, a typical embodiment can be found in claim 1:

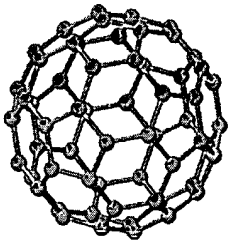
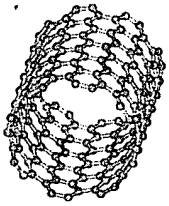
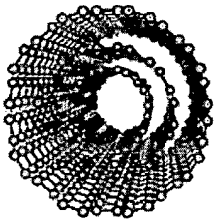
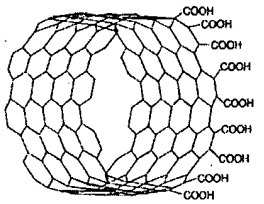
> 1. A method of forming a negative pattern of carbon nanotubes which comprises the steps of:
>
> (a) providing surface-modified carbon nanotubes by introducing double bond-containing functional groups into the surface of the carbon nanotubes;
>
> (b) dispersing the surface-modified carbon nanotubes in an organic solvent along with a photoinitiator to obtain a liquid coating composition;
>
> (c) applying the liquid coating composition to a substrate and evaporating the organic solvent by prebaking to provide a coating film on the substrate;
>
> (d) exposing the coating film to UV light through a photomask having a desired pattern to induce photo-polymerization of the carbon nanotubes in the exposed areas of the coating film; and
>
> (e) developing the coating film with an organic developer to remove unexposed areas of the coating film and to obtain a negative pattern of the carbon nanotubes.

Distinctions Of The Invention Over Aoki, Anazawa and Irving

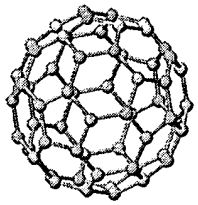
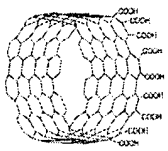
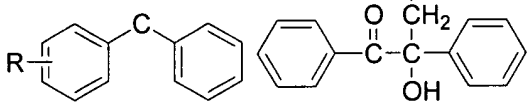
Aoki pertains to photosensitive materials comprising fullerene. The Examiner turns to column 2, lines 39-54 of Aoki, which discusses photosensitizing of fullerene with materials that can contain a vinyl group, an acryloyl group and a methacryloyl group.

Aoki fails to disclose photosensitizing carbon nanotubes. Aoki addtionally uses a fundamentally different route to surface modification.

The differences in structure between fullerenes and carbon nanotubes lead to different properties and chemistry, which are illustrated below.

	Fullerene C_{60}	CNT
Structure	 Ball type of carbon allotrope	  Single Wall Multi Wall **Nanotube**
Surface treatment	Addition reaction Chem. Rev., 1992, 92(7), 1487-1508.	**Scission by acid reaction** Acid fucntionalized and shortened by sonicating in a mixture of HNO_3 and H_2SO_4  - scission occurs preferably at both sides with COOH result in oxidation - cut SWNTs into many short pieces - broad distribution of open-ended SWNTs

Aoki performs surface modification of fullerenes using alkyl amine or azido compounds with methacryl chloride. In contrast, the present invention utilizes esterification in an acid. The two surface modification methods are compared below.

	(Aoki) US 5,561,026	10/713,254
Surface modification	Addition Reaction  + Alkyl Amine or Azido compounds → + Methacrylchloride → C60—NCH$_2$CH$_2$CH$_3$ (C=O, HC=CH$_2$)	Esterification Reaction  + by sonicating in a mixture of HNO_3 and H_2SO_4  + Acryl chloride → CNT—C(=O)O—C(=O)—CH=CH$_2$
Component		Copolymerizable photo initiator R = Acryl 

The Examiner turns to the teachings of Anazawa to take the position that carbon nanotubes and fullerenes are equivalent. The Examiner turns to paragraph 0006 of Anazawa which states:

> On the other hand, the carbon nanotube (hereunder, simply referred to as 'nanotube'), ***being a new material made up of carbon only in the same manner as the fullerene*** is discovered to possess the photosynthesis effect and a function as a semiconductor and the like, and is exposed to be utilized in various fields of the electronics industry. (Emphasis added)

However, this sentence can best be interpreted as stating that fullerenes and carbon nanotubes are dissimilar with the only common characteristics is that they are only made of carbon.

Further, Anazawa goes on to emphasize the differences between fullerenes and carbon nanotubes. Paragraph [0012] of Anazawa discusses the differences in solubility as a basis of separating the two materials:

> The soot containing the fullerenes is dissolved in an organic solvent such as benzene, and the fullerenes are separated and refined from the soot by the liquid chromatography method. Since the molecule size of the nanotube is quite large, there does not exist a soluble organic solvent; and the nanotubes are separated and refined from the soot by the ultrasonic method or the heat treatment method.

Paragraph of [0014] of Anazawa then remarks that fullerenes are soluble in an organic solvent such as benzene. As a result, Anazawa teaches that fullerenes and carbon nanotubes are not equivalent.

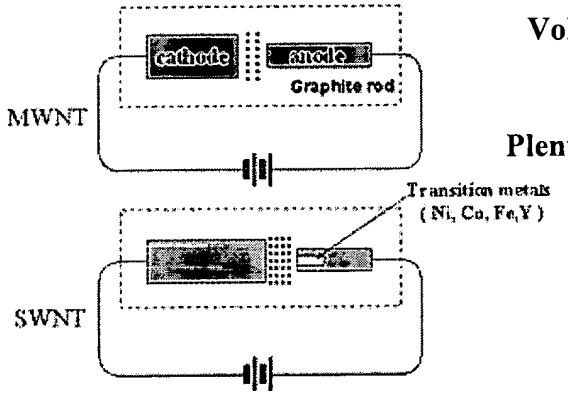
In contrast, claim 1 of the invention in step (b) recites "***dispersing*** the surface-modified carbon nanotubes in an organic solvent." However, if a fullerene is placed in an organic solvent, it would ***dissolve*** and not ***disperse***, as is taught in Anazawa. Anazawa therefore teaches away from the claimed

invention. A prior art reference must be considered in its entirety, i.e., as a whole, including portions that would lead away from the claimed invention. *W.L. Gore & Associates, Inc. v. Garlock, Inc.*, 721 F.2d 1540, 220 USPQ 303 (Fed. Cir. 1983), *cert. denied*, 469 U.S. 851 (1984). It is improper to combine references where the references teach away from their combination. *In re Grasselli*, 713 F.2d 731, 743, 218 USPQ 769, 779 (Fed. Cir. 1983).

Additionally the present invention and Anazawa use fundamentally different manufacturing process, as is illustrated below.

❑ Synthesis of Carbon Nanotube used in the invention (1)

Arc Discharge



Two graphite rods are placed between the electrodes in He chamber (separated by less than 1mm)

⇩

Voltage is applied across the electrodes (20V~40V,50A~100A)

⇩ The arc occurs

Plenty of electrons move to the anode and impact with graphite rod

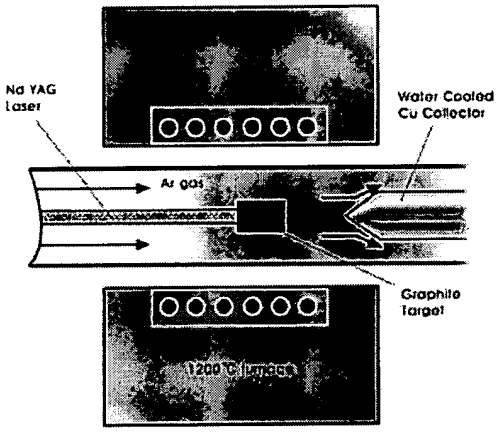
⇩

Carbon Clusters are condensed on the cathode

⇩ Low temperature on the cathode is necessary

Carbon nanotube is synthesized

Laser Ablation (Laser Vaporization)



Laser is radiated to the graphite target

⇩ Vaporization of Graphite

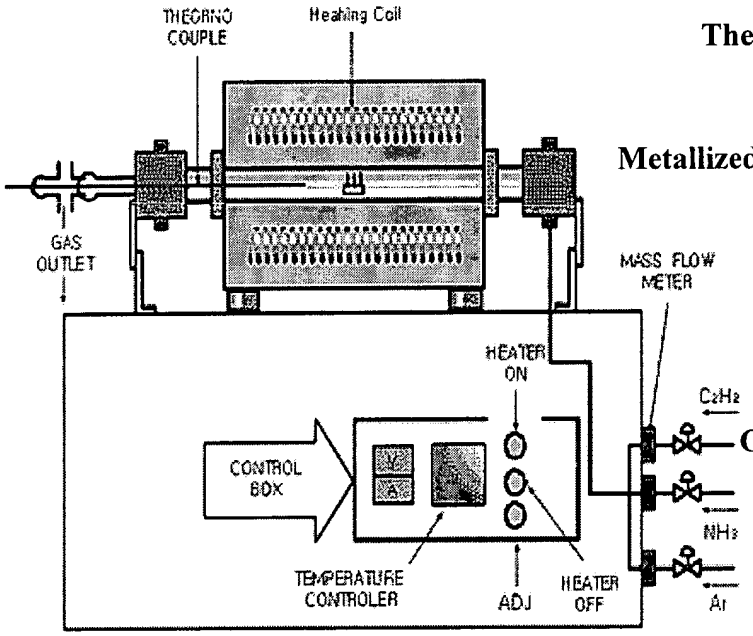
Vaporized carbon clusters are absorbed and condensed on the Cu Collector

⇩ Low temperature on the cathode is necessary

Carbon nanotube is synthesized

❑ Synthesis of Carbon Nanotube used in the invention (2)

CVD - Chemical Vapor Deposition



The substrate of Si or Glass is metallized by catalyst metal (Fe,Ni,Co)

⇩

Metallized substrate is placed on the carrier, then injected to a reactor

750℃ - 1050℃

Additional etching by using NH_3 gas

⇩

Grain is formed on the surface of catalyst metal on the substrate

⇩ C_2H_2 gas injected

Carbon nanotube is synthesized

- Carbon nanotubes grow on the grain formed after etching
- Grain : Embossing type of surface

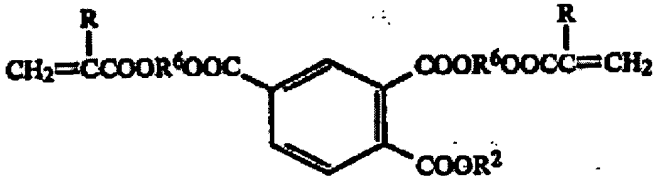
In contrast, Anazawa syntheses at low pressure with a carboniferous liquid state. Paragraph 0033 of Anazawa discusses that the manufacturing apparatus is provided with an introduction tube 15 that introduces a carboniferous liquid sstate material inot the discharge plasma inside the vacuum chamber 10 (see Figure 1 of Anazawa).

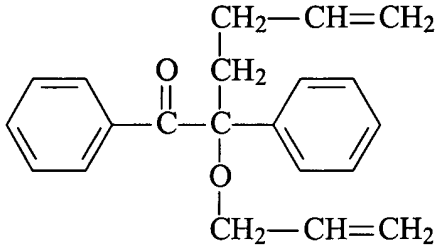
As a result, one having ordinary skill in the art would have no motivation to combine Anazawa with Aoki.

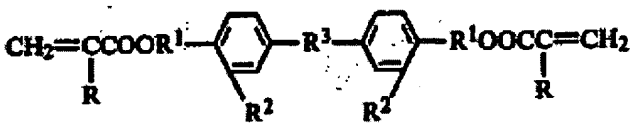
At page 3 of the Office Action, the Examiner admits that Aoki does not teach using the photoinitiator along with fullerene. The Examiner turns to Irving for these teachings. Irving at column 17, lines 19-45 gives examples of photoinitiators for photopolymerizations. However, Irving fails to disclose or suggest using these photoinitiators with carbon nanotubes. Also, Irving pertains to compounds having one acryloyloxy or methacryloyloxy groups. In contrast, the present invention uses a copolymerizable photoinitiator.

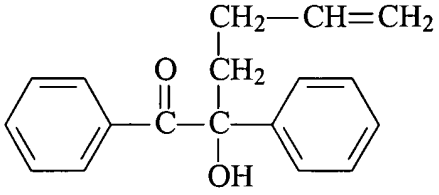
The differences between Irving and the photoinitiators of the present invention are illustrated below.

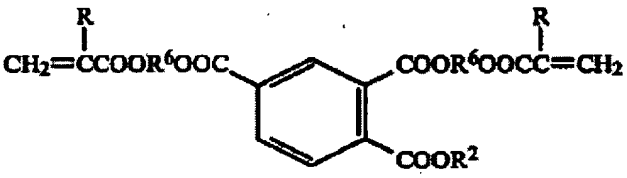
Irving (U.S. Patent 4,439,291) Present Invention

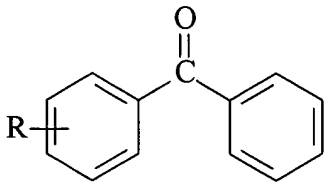




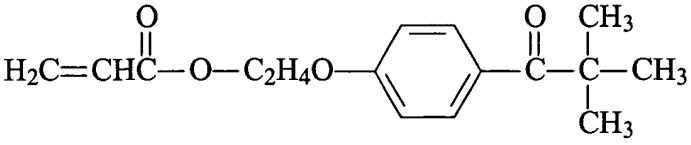


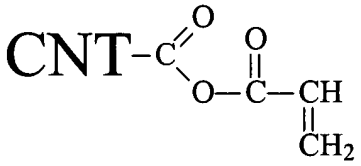






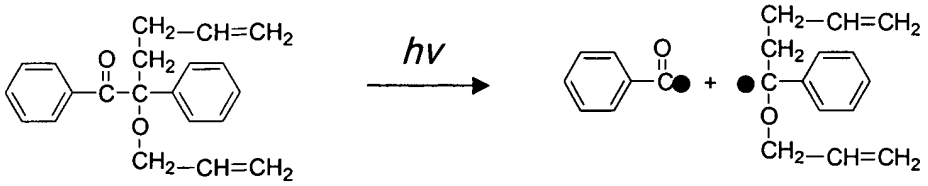
R = Acryl

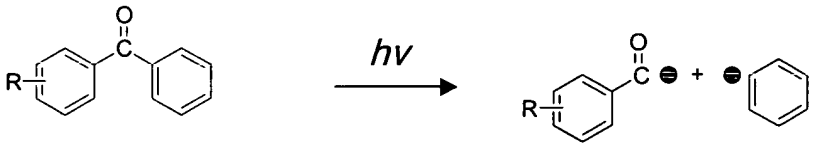




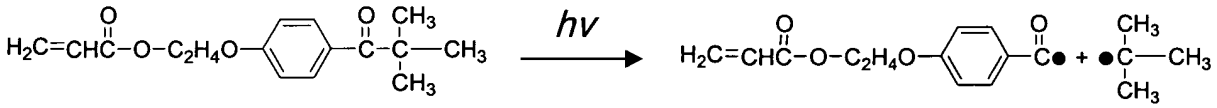
As a result, the compounds of Irving are not capable of the functioning of the copolymerizable photoinitiators of the present invention, which are illustrated below.

Copolymerizable photo initiator





Radical Radical
+ Monomer



Radical + Monomer Radical

As a result, there are fundamental differences between Aoki, Anazawa and Irving and the present invention:

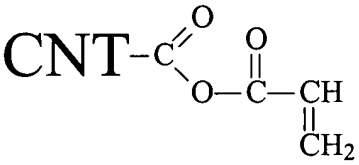
i) Aoki uses a ball-type of carbon allotrope that is surface modified by an additional reaction. The present invention is a carbon nanotube that can be acid functionalized and shortened, forming COOH at both sides. Photosensitive groups are introduced on the surface by esterifying COOH and acrylchloride. The present invention uses a photoinitiator to form radicals and

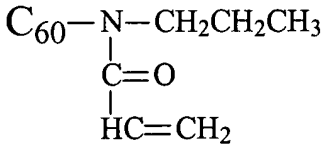
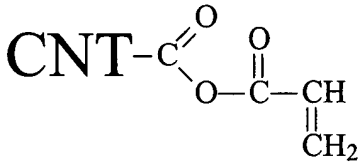
promote a UV reaction. The photoinitiator is also involved in photopolymerization as a monomer to increase efficiency.

ii) Anazawa teaches away from the invention and uses a fundamentally different method of synthesis. The present inveniton can substitute on all the surfaces of the carbon nanotubes, so there is no dependence on the characteristics of each type of nanotube produced by different methods.

iii) Irving uses a monofunctional compound. In contrast, the present invention uses a copolymerizable photoinitiator that can copolymerize with the carbon nanotube.

In summary, the differences between the applied art and the present invention are illustrated below.

Difference	Irving	Present Invention
Photosensitive Compound	One acryloyloxy or methacryloxy group	- Photosensitive CNT  - Copolymerizable photoinitiator - Copolymerizable monomer or oligomer

Difference	Irving	Present Invention
Surface modification method	Addition reaction 	Esterification reaction 
Difference	Anazawa	Present Invention
CNT making method	Low pressure with carboniferous liquid state	-Arc discharge -Laser vaporization -CVD

In order to better understand the differences between the present invention and the applied art, Jong Jin Park has prepared a slide presentation, which is attached to this paper.

Therefore the combination of Aoki, Anazawa and Irving would not motivate one having ordinary skill in the art to produce the invention of claim 1. A prima facie case of obviousness has thus not been made. Claims depending upon claim 1 are patentable for at least the above reasons.

This rejection is overcome and withdrawal thereof is respectfully requested.

Information Disclosure Statement

The Applicants thank the Examiner for considering the Information Disclosure Statement filed November 17, 2003 and for making the initialed PTO-1449 form of record in the application in the Office Action mailed March 22, 2005.

Foreign Priority

The Examiner has acknowledged foreign priority in the Office Action mailed March 22, 2005.

Conclusion

The Examiner's rejections have been overcome, obviated or rendered moot. No issues remain. The Examiner is accordingly respectfully requested to allow the application.

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact Robert E. Goozner, Ph.D. (Reg. No. 42,593) at the telephone number of the undersigned below, to conduct an interview in an effort to expedite prosecution in connection with the present application.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit

Account No. 02-2448 for any additional fees required under 37 C.F.R. §§ 1.16 or 1.17; particularly, extension of time fees.

Dated: June 22, 2005

Respectfully submitted,

By

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